Introduction

• **Scope**
  
  To introduce ABRACON’s 32.768kHz product offerings

• **Content**
  
  What is a Tuning Fork crystal? (At-cut crystal vs. Tuning Fork)
  Basic production flow
  Product offering
  Various packaging options
  Key points to consider for oscillator design
  Tuning Fork crystal based oscillator (ASHK series)
  Summary

This PTM is compiled to showcase ABRACON’s 32.768kHz product offering. It outlines primary difference between AT cut and Tuning Fork crystals, basic production flow, product offering, key features, circuit design consideration, 32.768kHz ASHK oscillator & ABRACON’s strengths
Beechman formulated that the frequency stability over temperature of an AT Cut Crystal can be approximated by a $3^{rd}$ or higher order polynomial.

\[
\frac{\Delta f}{f} = A_1(t - t_o) + A_2(t - t_o)^2 + A_3(t - t_o)^3
\]
The coefficients of this polynomial are directly dependent on the angle of cut. The ZERO Angle where the crystal frequency behavior is the flattest around 25°C is approximately 35° 15’ from the z-axis.
The frequency stability over temperature of a Tuning Fork Crystal can be approximated by a Parabolic Function.

\[ \Delta f/f = \text{Coeff} \times [(T-25)^2] \]
The typical temperature coefficient of the Tuning Fork Crystal is approximately 0.04 ppm / T²
At-Cut versus a Tuning Fork crystal

Generally speaking, the blank design is final package dependent. AT-Cut vibrates in Thickness Shear Mode whereas; Tuning Fork operates in Flexure Mode.
Basic production-flow follows the same sequence as the AT-cut crystal. The primary difference is in tuning the center frequency. There are several ways to achieve that including power shot and laser tuning.
ABRACON’s Tuning Fork Timing Products

<table>
<thead>
<tr>
<th>SMD crystal</th>
<th>Thru-hole crystal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Image</strong></td>
<td><strong>Part name</strong></td>
</tr>
<tr>
<td></td>
<td><strong>ABS06</strong> 2.0 x 1.2 x 0.6mm <em>Industry smallest package!</em></td>
</tr>
<tr>
<td></td>
<td>Ultra Low Profile, 32.768kHz</td>
</tr>
<tr>
<td></td>
<td><strong>ABS07</strong> 3.2 x 1.5 x 0.9mm</td>
</tr>
<tr>
<td></td>
<td>Low Profile, 32.768kHz</td>
</tr>
<tr>
<td></td>
<td><strong>ABS09</strong> 4.10 x 1.5 x 0.9mm</td>
</tr>
<tr>
<td></td>
<td>Ultra Low Profile, 32.768kHz</td>
</tr>
<tr>
<td></td>
<td><strong>ABS10</strong> 4.9 x 1.8 x 1.0mm</td>
</tr>
<tr>
<td></td>
<td>Ultra Low Profile, 32.768kHz</td>
</tr>
<tr>
<td></td>
<td><strong>ABS13</strong> 6.9 x 1.4 x 1.3mm</td>
</tr>
<tr>
<td></td>
<td>Molded Plastic, 32.768kHz</td>
</tr>
<tr>
<td></td>
<td><strong>ABS25</strong> 8.0 x 3.8 x 2.5mm</td>
</tr>
<tr>
<td></td>
<td>Molded Plastic, 30kHz to 165kHz</td>
</tr>
</tbody>
</table>

ABRACON is a one-stop-solution provider for 32.768kHz products. From legacy – cylindrical type packages to industry leading SMT low-Profile solutions, Abracon is well positioned to satisfy most if not all of your real-time clocking requirements.
Key design consideration for 32.768kHz Crystal Oscillators

U1: Inverter amplifier typically inside the µcontroller IC
Rf: Feedback resister to set bias for the oscillator loop. Value 10Mohm to 20Mohm
Rd: Damping resister to control drive level Value: 100kohm to 330kohms
C1 and C2: Load capacitors to control center frequency.

These values are to be optimized to meet <1.0uW drive level, while maintaining sufficient oscillation margin.
**ABRACON ASHK Tuning Fork Crystal Oscillator**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>4.0 x 2.5 x 0.9 mm</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>Available with 1.5V, 1.8V, 2.5V, 2.8V, 3.3V and 5.0V standard bias</td>
</tr>
<tr>
<td>Mature Product</td>
<td>Millions shipped</td>
</tr>
</tbody>
</table>

**Key features:**

- Ultra low current consumption with CMOS output (0.8µA maximum)
- Miniature ceramic package (4.0 x 2.5 x 0.9mm)
- Operating Temp -40°C to +85°C
- Start up time less than 1 second
- Tri-state function
- Pb-free reflow capable

ABRACON’s ASHK oscillator in 4.0 x 2.5 SMD package utilizes a Tuning Fork crystal. It features ultra low current consumption with a CMOS Output and the equivalent temperature behavior of a Tuning Fork crystal.
Summary

• Abracon offers a broad breadth of crystal & oscillator products for real-time clocking requirements

• Abracon’s clock crystals in cylindrical packaging are optimal for cost sensitive solutions

• High density board designs requiring ultra miniature devices can leverage Abracon’s SMT clock crystals and oscillator products, as small as $2.0 \times 1.2 \times 0.6 \text{ mm}$

• Further packaging miniaturization is planned

• For power sensitive applications, ASHK clock oscillator is an optimal choice drawing less than 0.8µA of total current
Thank You!

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